A Survey of Pollution and Resource Intensity Indicator Research in Taiwan

A report commissioned by The Policy Group of the US-Asia Environmental Partnership
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Acronyms and Definitions

CTCI	China Technical Consultants Incorporated
EPA	Taiwan's Environmental Protection Administration
EPE	Environmental performance evaluation
IDB	Industrial Development Bureau
IPC	Industrial Pollution Control Corp (subdivision of CTCI)
ISO 14000	Standard for environmental management system design prepared by the International Standards Organization
ITRI	Industrial Technology Research Institute
MOEA	Ministry of Economic Affairs
WRB	Water Resources Bureau

Introduction

Project Background

Since the 1987 Brundtland Commission report that defined sustainable development, managing the environmental impacts of growth has been a major theme in development policy at both a national and international level. In response, many of the world's developing economies have adopted the regulatory techniques and models used in the United States, Europe, and Japan (to a lesser extent) to control industrial pollution. However, in Asia, there is a growing concern that rapid industrial growth will eventually overwhelm the ability of current regulatory systems to maintain ambient environmental quality simply due to sheer volume of new manufacturing capacity.

In order to mitigate the impact of the rapid pace of growth, public policy must focus on reducing the pollution and resource intensity of industrial activity (also known as "delinked" or "dematerialized" growth). At the moment, most national level indicators and goals related to industry and environment focus on economic targets or tracking ambient environmental quality. Efforts to measure or guide dematerialized growth would require the development of indicator sets to measure the pollution/resource intensity on a national level as well as the establishment of relevant intensity goals or targets.

In Taiwan, the government has been increasingly interested in the potential applications of pollution intensity indicators on both a national level and the industry sector level. The Taiwan Environmental Protection Administration (EPA) and the agencies under the Ministry of Economic Affairs (MOEA) have begun to research pollution performance indicators sets that feature ratios of material, pollution, or resource intensity per unit product of output. The stated goals of the government-sponsored research include:

1) To provide the private sector with tools for use at the facility level to guide the development of cleaner production technology;

2) To allow policy makers to benchmark environmental performance within and between different industry sectors;

3) To establish resource efficiency benchmarks to guide public policy initiatives.

Program development is still in the early stage, but the efforts may be the first step towards establishing intensity or efficiency goals on a national level by individual agencies.

Objective

The research presented in this paper was undertaken from February to March of 1999 at the request of the Policy Group of US-AEP based in Washington. The goals of this project are to:

- Identify organizations conducting environmental performance metrics research focusing on materials/energy/water/pollution per unit of product;
- Determine who the funding organizations are and why they have commissioned such work;
- Describe the key indicators that are the focus of such work;
- Note which, if any, are already used in applied metrics work;
- Include recommendations by the researchers for development of additional metrics and for what purpose.

Methodology

The information contained within this report was gathered through a review of existing literature/research in Taiwan and interviews with the MOEA and four of its divisions (the Technology Department, Water Resources Bureau (WRB), Energy Commission (EC), and Industrial Development Bureau (IDB)—including the IDB's Seventh Division and the Coordination Office for Sustainable Industry), Taiwan Environmental Protection Administration (EPA), National Council for Sustainable Development (NCSD), Council for Economic Planning and Development (CEPD), National Science Council (NSC), Industrial Technology Research Institute (ITRI), Industrial Pollution Control Corps (IPC), Energy Technical Service Center (ETSC), Academica Sinica, several private sector organizations including the Taiwan Business Council for Sustainable Development, and several private and state-owned companies. The conclusions on private sector initiatives are still preliminary due to the limited number of interviews.[1]

Key Findings

In total, research identified nine relevant programs funded by agencies under the MOEA and the Taiwan EPA. While there is significant activity underway amongst a variety of agencies, there does not appear to be an overall coordination of research efforts to build a broad framework for policy. Each agency has initiated projects based on their individual needs and appears to have limited knowledge of the work underway in other agencies. As a result, while an extensive amount of data already exists on pollution intensity, it is spread amongst a number of different research organizations and government agencies. IDB currently has efforts underway to consolidate the existing data on progress towards waste minimization for a number of sectors that will likely include compilation of pollution intensity data. Completion of the consolidation effort will likely provide the basis for more coordinated research in the field.

In addition to the programs identified in this report, there are also government-sponsored research efforts to identify "sustainable development indicators" for use on a national level.[2] Such indicators tend to focus on measures of environmental quality, social development, and land use planning, and do not have a significant

[1] Interviews included representatives from the power, chemical, information technology, paper, and cement industries.

[2] Implementing organizations tend to be university professors and scholars rather than organizations such as Industrial Technology Research Institute (ITRI) or Industrial Pollution Control Corps (IPC) that is attached to China Technical Consultants Inc. (CTCI).

industrial component. This includes an extensive effort supported by the National Science Council to develop indicators for measuring progress towards sustainable development and an accompanying database. The indicators will likely be used by the National Council for Sustainable Development in monitoring national progress towards sustainable development.[3]

[3] Previously, the National Council on Sustainable Development (NCSD) was chaired by a Minister-without-portfolio and had limited political leverage over the various government ministries. In early 1999, the Vice-Premier became the Chairman of the NCSD which will likely significantly increase the status and influence of the Council. The National Science Council commissioned an indicators project on their own initiative, but the NCSD may now be interested in using the resulting system to guide their policy development.

Background on Taiwan

Taiwan's economy has seen tremendous growth over the last thirty years, moving from a per capita GNP of less than US$ 2,000 to becoming a major industrial producer with a per capita GNP of more than US$ 13,000. Taiwan's industrial growth began in the 1960s with the development of a light manufacturing and assembly industry based on textiles, leather goods, and food processing. Earnings from exports provided the capital to fund the development of a more sophisticated industrial base in the 1970s that depended on heavy industries such as steel, petrochemicals, basic consumer electronics, and pharmaceuticals. During the 1980s, the government began to shift its economic policy focus towards promoting high value-added industries such as computers, advanced electronics, and specialty chemicals.

Industry and the Environment

As in most countries, environmental concerns were not a priority during the early stages of industrialization and industrial loading has accounted for a significant amount of the overall pollution in Taiwan. The Taiwan EPA estimates that more than 30 percent of river pollution comes from industrial sources. Industrial solid waste is estimated at 18 million tons per year—more than double the volume of municipal waste.[4] The majority of the sulfur oxide (SOX) and nitrogen oxide (NOX) come from industrial sources.

Starting in the early 1980s, Taiwanese public began to demonstrate increasing concern over environmental issues through protests of factories perceived as being polluters. While the protests caused considerable waves of concern within industry and government, few companies became highly systematic or proactive in their attempts to improve their environmental performance.

In 1988, the government placed the environment firmly on the political and business agenda with the establishment of the Environmental Protection Administration (EPA) and the passage of the Solid Waste Disposal Act. Over the next five years, additional legislation was passed to regulate air quality (1991), water quality (1992), environmental impact assessments (1994), and control of hazardous substances (1988). In each case, the laws established rigorous standards comparable to those of industrialized nations.

Shift in the Policy Paradigm

Taiwan's environmental policies are determined primarily by the Taiwan EPA in conjunction with the Industrial Development Bureau (IDB). The Taiwan EPA is charged with protecting the ambient environmental quality through monitoring and regulating of industrial pollution output. The IDB is responsible for guiding the

[4] Source: Presentation by the Taiwan EPA on industrial solid waste to the American Chamber of Commerce

development of Taiwan's industrial base and working with industry to improve overall economic competitiveness. As part of their responsibility to improve competitiveness, IDB also works with industry associations and their members to improve the overall environmental performance of highly polluting sectors. While the policies of the two agencies are meant to be complementary, the agencies often have difficulty cooperating due to their different emphasis. The IDB seeks to guide through training, tax breaks on equipment, and other incentive measures and is inclined to be conservative in pushing for improvement. The Taiwan EPA, on the other hand, is designed to play a watchdog role and aggressively pursue improvement in ambient environment quality through the establishment of emission standards, facility inspections, and other traditional policy tools.

From 1988 through the early 1990s, the Taiwan EPA relied primarily on a command-and-control regulatory approach. The Taiwan EPA set effluent and emissions standards for air and water and sought to enforce compliance through self-reporting mechanisms supplemented by field inspections. Companies responsible for large volumes air pollution emissions and wastewater effluent were required to apply for a discharge permit and then report to the Taiwan EPA on a regular basis on their emissions. In total approximately 10,000 permits were issued separately for each category (air and water).[5]

While the Taiwan EPA was developing its regulatory regime, the Industrial Development Bureau (IDB) within the Ministry of Economic Affairs (MOEA) started a number of programs to help reduce the environmental impact of Taiwan's manufacturing activities. IDB began offering financial incentives such as low interest loans for the purchase of pollution control equipment and extensive technical guidance programs to assist companies in improving their environmental performance.

The mid-1990s saw a shift in policy away from the traditional command-and-control regime to a more diversified policy approach incorporating standards, pollution fees, and voluntary initiatives such as ISO that helped lay the foundations for future metrics work. The policy shift was driven primarily by a desire to develop strategies that would lead businesses to proactively seek ways to improve their environmental performance. The Taiwan EPA's experience in the late 80s and early 90s demonstrated that "command-and-control" approaches had very distinct limits due to limited manpower of the Taiwan EPA's inspection arm and the absence of a culture of compliance. As a result, new strategies were required to motivate businesses to proactively seek to improve their performance. Among the key elements in the new policy approach was the introduction of ISO 14001 and the simultaneous promotion of the concept of cleaner production.

In the mid-1990s, IDB began an aggressive ISO 14001-promotion campaign that has already made Taiwan a world leader with more than 400 certified companies. Many of Taiwan's largest companies now have internal pollution tracking systems that are

[5] The obligation to apply for a permit is determined based on the volume of emissions. Each group of permit holders (air permits and water permits) includes approximately 10,000 companies. In 1998, the EPA extended the permitting system to include solid waste with the establishment of an internet-based reporting system to track solid waste generation. At the moment, only a small portion of the waste generators in Taiwan are required to report, but over time EPA plans to expand the system.

capable of providing basic data for performance benchmarking. Even more important, ISO certification has committed many large companies to setting regular targets and pursuing continuous improvement. The next step in IDB's ISO efforts will likely be promotion of the soon-to-be-released ISO draft standard on Environmental Performance Evaluation (EPE). If pursued aggressively, promotion of the ISO EPE models will likely lead to the gradual standardization of performance evaluation systems within industry sectors.

While the ISO promotion efforts were underway, the IDB and Taiwan EPA also began to jointly promote the concept of Cleaner Production (CP) and pollution prevention through technical guidance programs and seminars. The programs helped focus resources and training on quantification and benchmarking of production efficiency in terms of pollution and resource usage. It is not clear at this point in time if ISO and cleaner production concepts have actually led to significant improvements in industrial environmental performance in Taiwan. However, these two broad-based initiatives have increased focused attention on the concept of continuous, *measurable* improvement (primarily at the facility level). A potential next step would be to move the concepts of continuous, measurable improvement to a national level as a manner of testing the success of government policy in addressing pollution issues or for use in goal-setting practices.

As ISO, Cleaner Production, and Pollution Prevention have been driving interest in performance metrics targeting pollution, growing concerns over resource scarcity have led to new research in the field of water and energy intensity.[6] Both the Water Resources Bureau and the Energy Commission are looking at benchmarking current levels of efficiency in order to determine resource allotments for new investments. Interest in developing more baseline data to identify opportunities for improved energy efficiency has grown significantly in the wake of the Kyoto Conference in 1998 and increasing international pressure to reduce greenhouse gas emissions.

Environmental performance metrics represent a new area of policy research in Taiwan. Metrics serve as a potential bridge to link many of the policy elements already incorporated into the Taiwan EPA strategy as well as new initiatives in corporate environmental reporting and community disclosure. Despite a strong interest in environmental performance metrics, there is no "government" plan for developing indicator sets for use in policy design. The existing metrics research projects have been commissioned independently by several different agencies based on their own internal needs and current policies. The projects tend to be mid-sized in terms of budget (20,000 - 40,000 US$ per year) and are often managed by mid-level officials.

Although it is still not clear how these programs will be applied in policy, stated goals of the programs include:

1) To provide the private sector with tools for use at the facility level to guide the development of cleaner production technology;

[6] Officials at both the Water Resources Bureau and the Energy Commission indicated that their efforts were at least partially driven by the concerns of high-ranking government officials over resource scarcity.

2) To allow policy makers to benchmark environmental performance within and between different industry sectors;

3) To establish resource efficiency benchmarks to guide public policy initiatives.

Motivations for pursuing approaches involving metrics tend to vary by agency. The rationale appears to be tied more to domestic needs than international drivers/motivators.

Metrics Research in Taiwan

Current Research Projects

This document identifies a total of nine programs that include research on pollution and resource intensity and that have been largely driven by bureaus within the Ministry of Economic Affairs. While all programs include pollution/resource intensity indicators, they are typically only one of a number of indicators used. The bureaus have primarily developed these programs independently of each other without coordination by a central agency or policy-maker. In addition to the pollution and resource intensity indicator research projects reviewed in this paper, there are also separate efforts underway to develop broad-based sustainability indicators similar to those associated with Agenda 21 programs in other countries. Indicators used in "sustainability indicators" are based on ratios (as opposed to total loading) and tend to focus on data related to quality-of-life or the state of development of households connected to the national sewer system. These programs tend to be supervised by Taiwan EPA and were not addressed as they do not emphasize measurements of intensity on a per product basis or the industrial issues associated with sustainability.

The Funding Agencies

While there is a significant amount of work underway in Taiwan, it is not coordinated by any one agency. A number of agencies—including the Environmental Protection Administration (EPA), Industrial Development Bureau (IDB), Water Resources Bureau (WRB), and Energy Commission (EC)— have developed initiatives based on the individual agency's needs or goals. The IDB, WRB, and EC are all under the Ministry of Economic Affairs (MOEA). Over the course of researching this paper, agencies demonstrated varying degrees of awareness regarding the details of projects underway in other organizations. (Appendix One provides a brief introduction to the different agencies)

The Implementing Organizations

The majority of the research work related to industrial pollution and resource usage has been contracted to the government-related Industrial Technology Research Institute (ITRI), Energy Technical Service Center (ETSC), and the Industrial Pollution Control Corps (IPC) within China Technical Consultants Inc (CTCI). Two universities are working on projects related to resource and pollution intensity indicators: Academica Sinica (Prof. Liang Chi Yuan is focusing on carbon dioxide (CO_2) reductions) and Tamjiang University (focusing on water usage). (Appendix One offers a brief introduction to the implementing organizations)

Public-Private Cooperation

Most of the research projects identified in this report have relied on voluntary participation by industry to obtain data. Data is typically gathered through broad surveys to a large sample of size of companies within a given industry sector followed by visits to a select number of facilities. Surveys often request confidential

information on production and pollution output, and many companies are reluctant to supply to the full range of data required. In the case of industries dominated by small, highly polluting companies, it is sometimes impossible to gather accurate data due to the lack of environmental expertise on the part of the companies. Industry players tend to be more comfortable sharing information with IDB than the EPA. Interviews with larger companies revealed a growing interest in benchmarking individual performance against industry averages which may encourage further cooperation between government and certain industry sectors. At the moment, industry has neither taken a position against development of environmental performance metrics for policy use, nor in its favor.

Existing Data Sets on Pollution/Resource Intensity

A significant amount of raw data on pollution intensity for a number of industry sectors exists in Taiwan, but it is spread throughout numerous reports and databases within ITRI, IPC, and various government agencies. A cross-section of companies report on total emissions (water, air, solid waste) to the Taiwan EPA, which uses existing raw data on pollution intensity to provide technical guidance to companies on pollution control. This information is not considered "public domain."[7] In the past, competition for government contracts between the various implementing organizations limited the amount of raw data exchange and consolidation.[8] In a recent effort to rationalize databases, IDB has initiated a multi-year effort to consolidate the data previously generated from technical guidance over the last several years on waste minimization.

Types of programs identified

Broadly speaking, pollution metrics programs in Taiwan fall into three types:

1. Resource efficiency measurement
2. Industry sector assessment
3. Self-auditing tools for businesses to apply at the facility level

All three types of programs use similar metrics, but the depth and focus of the indicators applied vary. In general, most Taiwanese programs use per unit product measurements as part of their measurement metrics portfolio, but the importance of ratio measurements based on product varies depending on the program goals. For sector level assessment of industrial pollution or resource usage, ratios are often defined using financial measures as the denominator to allow easier consolidation and comparison of data from different industry sectors. One point worth noting is that Taiwanese researchers do not always draw a clear distinction between metrics used for external reporting needs (public relations) and the metrics used for internal

[7] Taiwan typically gathers data for broad-based technical guidance programs through a combination of surveys and site visits. On a voluntary basis, companies provide information that is kept confidential in order to encourage honest and accurate reporting. While the government agency who commissioned the project has access to the aggregate information and analysis, the actual data itself remains with the implementing body.

[8] According to researchers, each implementing organization has developed its own industry performance databases which become an important part of their qualifications in drafting project proposals.

needs (process engineering). Use of metrics in environmental communications in Taiwan is just beginning and the distinction does not yet have a high level of significance.

Resource efficiency programs are primarily driven by concern over scarcity of resources and the need to determine rational/reasonable allocation. Currently, both the Water Resources Bureau (WRB) and the Energy Commission (EC) are researching resource intensity by industry sector with the ultimate aim of developing industry averages to guide future allocation of usage rights. In terms of research, the WRB appears to have moved further than the EC in terms of collecting actual benchmarking data towards this goal. However, it is likely that pressure will grow on the EC to benchmark energy usage and drive increases in efficiency as part of Taiwan's strategy to meet the new Kyoto Protocol requirements.[9] Resource efficiency programs are primarily sponsored by the Water Bureau, Energy Commission, or other agencies responsible for managing the allocation and use of natural resources.

Resource efficiency programs administered under the Energy Commission and Water Resources Bureau have sought to document resource usage by industry sector both in terms of overall volume and as ratios per unit product or square footage of factory. In the two research programs currently underway, ratio metrics are embedded within a broader set of metrics that focus on aggregate usage. Such a pattern is not surprising given the fact that efficiency efforts were generally low profile in the past and aggregate usage was more significant for allotment planning.[10] However, recent domestic and international trends have placed a new emphasis on resource efficiency, so ratio measurements will likely grow in significance.

Industry sector assessment programs develop indicators and databases to allow regulators and the private sector to:

1) Benchmark individual company performance within the context of its industry peers;

2) Develop aggregate data on a sector level to allow government agencies to compare the relative environmental footprint vs. economic value for different industry sectors.

The results of sector assessments can serve as inputs for either micro- or macro-level policy decisions. On a micro-level, assessments would identify the best and worst performers within an industry sector and could provide the basis for prioritizing technical guidance on cleaner production, pollution prevention, etc. On a macro-level, regulators view sector assessments as a potential tool for making decisions regarding future industrial development as a whole, based on the relative environmental impacts and economic contributions of different sectors.[11] At the

[9] The Kyoto Protocol was developed in 1998 to reduce global greenhouse emissions.

[10] Efficiency programs have been in place for over twenty years, but officials in the Water Resource Bureau and researchers from the Energy Technical Service Center indicated that the programs were relatively low-profile for many years. However, growing demand for limited resources over the last ten years has made achieving efficiency improvements of increasing strategic importance.

[11] Despite the interest expressed by government regulators in the concept of using

moment, some sector assessment programs only seek to develop indicator frameworks without actually establishing an accompanying database of information for ongoing use. Taiwan currently has two research programs underway to develop indicator frameworks for three industry sectors: pulp & paper (through IDB), cement, and steel (through Taiwan EPA).

The two sector assessment programs identified use different models for structuring their metrics. The Taiwan EPA project to develop cement and steel industry indicators is still in the process of selecting its final indicators, but will most likely settle on 10-15 that are divided into the categories used by the ISO EPE standards (environmental condition indicators, management performance indicators, and environmental performance indicators). [12] Environmental condition indicators are heavily weighted towards per unit product ratios, but the performance indicators (management/environmental) include a broader mix ranging from operational costs to qualitative questions regarding the structure and implementation of the environmental management system.

IDB's Industrial Sustainability Indicators for the Pulp & Paper Industry has chosen to use the "triple bottom line" (social-economic-environmental) as its structure and has developed indicators under each of the three headings. The pulp and paper industry project's focus on sustainability as opposed to solely focusing on environmental performance has led to the development of a much broader scope of indicators.

Programs to develop self-auditing tools for businesses to use at the facility level – establish indicators and measurement guidelines to assist companies in identifying cleaner production opportunities. Usually, such programs provide a set of indicators and a methodology for their application in the form of a report or handbook. Cleaner production handbooks have already been developed for the polyurethane, leather, and integrated circuit industries. In 1998, ITRI completed a separate and more detailed study on cleaner production indicators for the food processing industry. A new program is now underway to develop a methodology to assist companies in the integrated circuit and printed circuit board industries in selecting environmental performance indicators for measuring their performance. All of Taiwan's cleaner production programs have been sponsored by MOEA-related agencies.

As part of its efforts to promote cleaner production, the IDB has commissioned three projects to assist companies in developing indicators to apply to their own internal analysis. The first project relied on a very simple set of three "per unit product indicators" (total waste, energy use, hazardous exposure) and a methodology for applying these three indicators throughout the production process.[13] The second "Cleaner Production Indicators for the Food Processing Industry" under ITRI project relied primarily on intensity ratios that use financial measures in the denominator.[14] The third and more recent EPE project focuses on developing a methodology for selecting appropriate indicators to reflect the unique aspects and goals of the

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value/environmental footprint to guide policy development, there do not yet appear to be any concrete actions to incorporate sector assessments based on pollution intensity metrics into policy-development.

[12] Source: personal communications, Industrial Pollution Control Corps

[13] See "Program Profiles" in this paper for a more detailed explanation.

[14] See "Program Profiles" in this paper for a more detailed list of indicators.

individual factory as opposed to selecting a set of generic indicators for use by all factories.

Private Sector

Efforts to measure data are also underway within the Taiwanese private sector. Many of the larger Taiwanese companies in the semi-conductor and chemical industries report that they now have systems in place to that give them the capability to measure their environmental performance on a per product basis. Industries in which products and production processes change frequently, such as information technology, find the per product measurement of limited value, but most still appear to maintain records. While many companies appear to be somewhat unstructured in their use of metrics, a few companies such as China Steel have developed highly structured sets of metrics divided by category (Environmental Condition Indicator, Operational Performance Indicator, Management Performance Indicator).[15]

There are currently two initiatives to compile Taiwan's first corporate environmental reports for release to external stakeholders. A group of approximately 12 companies within the Taiwan chapter of the Business Council for Sustainable Development are planning to release a combined report which will include ratio data on a per product basis.[16] In addition, China Steel also has plans to release a corporate report in the year 2000. These initiatives are a positive indication of increasing corporate commitment to the environment and to public disclosure, but will be based mostly on already-available data and are unlikely to spur significant new research on indicators and measurement techniques.[17]

It appears that a substantial number of large companies in Taiwan now use measures of pollution output or resource usage per unit of product manufactured in combination with other measures (such as total pollution volume) to set environmental targets. Per unit product ratios are used most commonly in industries that manufacture relatively homogeneous products such as paper, cement, and commodity chemicals, where products have similar characteristics and can be more easily lumped together for measurement purposes. In addition to goal-setting applications, companies also use ratios as a way to identify opportunities for pollution prevention and cleaner production within a given production line. However, it should be noted that Taiwanese companies perceive pollution intensity ratios as useful for identifying cleaner production opportunities only when applied to the same production line or two lines with the same or highly similar process technology and type of equipment.

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[15] This description of China Steel's environmental performance metrics system is based on interviews with China Steel personnel and published papers including: "Cleaner Production Experiences of China Steel Corporation" by Kuo-ching Liu of China Steel.

[16] In North America and Europe several environmental performance metrics research projects have been initiated by either formal or informal groupings of private sector representatives. Examples would include the project initiated by the American Chemical Engineers Association in 1997 or the work on eco-efficiency by the World Business Council for Sustainability.

[17] According to the Taiwan BCSD, their reports will likely be based on metrics work developed by the World Business Council for Sustainable Development (based in Geneva, Switzerland) with some modification to reflect Taiwan's specific situation.

Technical issues in use of per unit product ratios

Researchers and policy makers in Taiwan indicated a number of issues and challenges surrounding the use of per product unit ratios for policy applications, including:

1) Unit measurement's suitability to policy goal
In principle, environmental performance evaluation measurements can be used for comparisons at either the sector level or the facility level. Sector level measurements usually involve: 1) comparing the environmental efficiency of multiple industry sectors against each other (e.g. cement industry vs. steel industry); or 2) benchmarking the performance of one factory against all other factories within the same industry sector. In either case, the goal of performing the comparison is to allow government to establish policies to encourage the development of an industrial structure that provides the most value through its products and services with the least environmental impact.

For sector level measurements, the use of "product" in the denominator poses a number of challenges. Not all companies produce the same basket of products and sector level measurements require combining a broad number of individual products into a single composite "product" measurement or a small number of general "product" categories. When companies have similar product baskets, measurements of intensity can be useful for identifying cleaner production processes. However, when product baskets vary, the results of pollution intensity comparisons on a per unit product basis can be misleading since they fail to take into account the relative value obtained by the user or society for the pollution generated and resources consumed.

For example, cars that require twice as many resources to manufacture, but are three times as durable would perform poorly on a measure of strict resources used per unit of product. However, when the value generated over the product life-cycle is taken into account, the more resource intensive car may actually be the preferable alternative.[18] Another example would be that of two factories producing electronics products. The product basket with the higher pollution intensity ratio may be manufacturing a range of products that are of strategic importance to maintaining infrastructure services while the company with the lower ratio is manufacturing leisure products such as stereo systems that would not be considered "indispensable."

When comparing across sectors, "product" becomes even more problematic. Any useful comparison requires a common denominator for the measurement to have meaning. However, comparing solid waste generated per ton of cement manufactured with tons of solid waste generated per unit of refrigerator manufactured does not have any relevance to selecting preferred policy options.

One possible solution to the complications of using product in the denominator is to

[18] Calculating value-added over product life-cycle would also require calculating environmental impacts over product life-cycle. Resource and pollution intensity ratios are most useful for comparing industry sectors. However, efforts to compare products are probably better done with life-cycle analysis.

use a measure of economic value such as sales or value added under the assumption that it reflects some measure of the utility of the product to the consumer. Using a non-environmental "value" metric would provide a potentially useful quantitative basis for structuring industrial development policies to encourage the growth of low-polluting, low-resource intensive industries. At the moment, there does not appear to be a strong interest within the Taiwan government to pursue these applications.

The second primary application of ratios is to identify opportunities to achieve higher levels of cleaner production within a given facility, however, such efforts require very narrowly focused definitions of "product." Sectors such as semi-conductors that frequently change their product or production process find it difficult to identify the causes of variations in pollution level and characteristics through ratios that compile data for a range of products. Once production process conditions change significantly to manufacture a new product, the previously collected data no longer provides a useful baseline for analyzing cleaner production opportunities.

2) Defining "product"
Few factories manufacture a single product, so companies are often forced to either lump all production from a single facility under a single "product" category for purposes of analysis or focus only on a single production line. For industries with a relatively homogeneous product such as cement, paper, basic chemicals, or other commodities, products can usually be easily grouped. Industry sectors such as manufacturers of information technology expressed the view that grouping of products makes the data useless for identifying opportunities for improvements within a factory due to significant design differences between production lines.

3) Adjusting for changes in ratio measurements due to the production cycle
Ratios are essentially a measure of efficiency and many companies find that their overall efficiency is partially a function of their production volume over the course of a month. Companies from the chemical and paper industries reported that their ratios improve during months with higher production even though they have not implemented any environmental improvements. Companies who choose to define "product" as a the total volume of output from a given facility will also see changes in the ratio as a result of the mix of products manufactured in a given month. For sectors such as the chemical industry, the variation can be quite significant.

4) Ability to gather accurate data
Government agencies seeking to use per unit product data in Taiwan have encountered reluctance on the part of industry to disclose the details of their production, resource usage, and pollution output. Many researchers and government agencies interviewed feel that there are also serious distortions in the information provided by companies who voluntarily participate in studies. Some distortions can be identified when teams of government engineers conduct detailed analyses of factories using techniques such as mass balancing[19], however, the combination of Taiwan's large number of factories and the limited resources of

[19] One of the techniques used in assessing environmental footprint. It means setting up a spreadsheet that allows you to track your material flows based on mass (weight) from the start of the production process to the finish. If one accurately accounts for all inputs, pollution outputs, and final products, one should be able to balance your mass (i.e. everything is accounted for).

government renders such inspections impractical for obtaining data on a continuous basis.[20] Any wide-spread use of performance metrics would require developing a methodology to gather reliable data on a consistent basis – a significant challenge at the moment.

5) Lack of international data sets for comparison
Taiwanese agencies conducting metrics research report difficulty in finding pollution intensity data from other countries to serve as a point of reference. The utility of the environmental performance data that is readily available is often limited due to differences between Taiwanese research and work in other countries, in terms of indicators selected and the measurement methods used. Even basic elements such as the definitions used for industry sectors can contain significant variations. At the moment, there are no international cooperative research projects on environmental performance metrics between Taiwanese and foreign agencies.

6) Maintaining updated data to reflect changes in production processes
In order to develop useful data for benchmarking, it is necessary to track pollution and resource intensity over a period of years, both to capture changes in standard production processes as well as develop data sets free from distortions due to annual fluctuations. To date, most of the projects sponsored by government agencies have been implemented for only one or two years, which is insufficient to establish a reliable database. The most historically complete databases are likely those at the Energy Commission.

[20] These views were repeatedly echoed by both researchers and government officials across a wide-range of agencies.

Policy Applications

Current Utilization in Policy

While there appears to be considerable activity towards the development and evaluation of pollution intensity metrics, the metrics themselves have not yet been integrated into the mainstream process of policy formation and national goal setting. Many of the programs identified are less than two years old and are still in the process of establishing the framework for their analysis and lack complete data sets to allow policy makers to act. The next step will be to begin gathering data and benchmarking environmental performance amongst companies and industry sectors. Once databases are developed and the strengths and weaknesses of various indicator sets are better understood, policy-makers will be in a position to identify the best policy applications of indicators. The more advanced programs are already beginning the benchmarking process and many researchers in the field believe that the IDB may begin attempting to set national industrial environmental performance targets within the next five years.

To fully develop the long-term potential of the programs, it will be necessary to broaden the number of industries covered and consolidate existing data. At the moment, most programs focus on one to three industries and sometimes overlap with work previously done. In order to make macro-policy decisions regarding industrial development, it will be necessary to develop profiles for a wide range of industry sectors. For example, decisions pertaining to air quality or CO_2 would require full data sets on the key industries responsible for air pollution.

The Industrial Development Bureau has commissioned IPC to lead a project to consolidate all of the environmental data gathered through technical consulting/guidance projects led by IPC, ITRI, and the Foundation for Taiwan Industry Service in 10 sectors over the last several years. IDB's main interest lies in evaluating the waste minimization achievements of their guidance efforts, but the data will likely also include pollution intensity information. Depending on the structure of the database upon completion (estimated to be two to three years from now), it may fill the data gap outlined in the previous paragraph.

Issues in Developing Policy Applications

Geographic scope of sampling - For agencies such as the Taiwan EPA's Water Quality Protection Bureau, policies to drive improvements in national averages will not necessarily help accomplish their goals of improving ambient environmental quality in Taiwan's most polluted river systems and water bodies. Since industry sectors are not evenly distributed geographically, improvements in the national intensity averages for a given sector may have little or no influence on the ambient water quality in the geographic areas of highest concern for regulatory agencies.[21]

[21] For example, a majority of Taiwan's semi-conductor industry is focused in a single industrial park in northern Taiwan. Improvements in semi-conductor industry performance would have little impact on heavily polluted rivers in Southern Taiwan. The EPA's Water Bureau currently prioritizes efforts by targeting the largest pollution sources along the rivers or water bodies with the highest pollution

However, while national level indicators may not be appropriate, the same metrics could potentially place a useful role if used on a smaller geographic scale (e.g. pollution intensity of industries operating in a given river basin).[22]

Defining goals - In the environmental arena, emissions standards have proved invaluable for in achieving a minimal level of environmental performance, however, finding methods to drive further improvements beyond basic compliance has proved challenging. Similarly, a fixed efficiency standard may accomplish the goal of forcing industry to improve efficiency to within the standard, but it would not guarantee continued improvement by industry. One alternative would be to define efficiency goals in terms of a required percentage reduction in intensity on a periodic cycle as opposed to a fixed efficiency target. Defining goals in terms of percentage improvement would potentially also circumvent some of the prolonged public debate typically associated with the tightening of emissions or performance standards.

levels. Therefore, improvements in national averages will not necessarily lead to achieving goals for the improvement of areas considered to be of top priority.

[22] The EPA's Water Quality Bureau has expressed an interest in methods for using benchmarking to drive environmental improvement in sewage treatment facilities.

Conclusion

The Taiwanese government appears to be moving in the direction of incorporating intensity targets and measures into national policy. Integration has been slow to date due to 1) reluctance within certain agencies to adopt new approaches; 2) concerns over the political implications of setting targets based on pollution or resource intensity; 3) the fact that most programs are still at an early stage in their research. [23] Resource management agencies (Energy Commission and the Water Resources Bureau) have moved the furthest to date in terms of their research. However, a substantial number of policy makers perceive efficiency standards to amount to de facto limits on the growth of certain industry sectors, and feel that industrial growth should be dictated by the market rather than government. The EC and WRB have both indicated that benchmarks will initially be used as a point of reference rather than as a firm efficiency standard. Given the number of projects recently commissioned by IDB and Taiwan EPA on pollution and research intensity, it is quite possible that ultimately IDB or EPA will move faster than the EC and WRB to begin incorporating metrics into policy.

The speed of the integration of programs such as inter-sector comparisons into mainstream policy-making will very much depend on the ability of the sponsor agencies to push for change within the existing governing institutions. Most of the agencies recently established to deal with sustainability challenges such as COSI or the NCSD are relatively weak in terms of budget, manpower, and influence. Part of their mandate is to educate other departments within their own Ministry as well as serve as a bridge to bring together other Ministries to address inter-disciplinary issues. Many of the organizations are outside the mainstream decision-making process and have limited leverage to push the development of non-traditional approaches to industrial policy/pollution management.

One area where political concerns could potentially drive the development of efficiency measurements is that of the so-called “strategic industries”. Many economic planners argue that certain industries such as steel or cement are indispensable to Taiwan’s national security regardless of their cost in terms of resource demands or pollution.[24] In cases where environmental performance has become unacceptable to the regulatory authorities or the general public, but elimination is not an option, policy makers will have to settle for demanding continuous improvement. Environmental performance metrics such as pollution intensity ratios will provide a potentially useful way to set improvement targets and structure performance-based programs.

Many researchers in Taiwan have also encountered difficulties in identifying international databases suitable for benchmarking their efforts. While there is considerable interest in Taiwan on developing data exchanges, it appears that

[23] Many policy-makers are still exploring the potential of pollution intensity indicators. As the research focus moves from developing methodologies for gathering data and into detailed benchmarking, the pace of integration may increase.

[24] This view is particularly strong in industry-related agencies such as the MOEA or the Council for Economic Planning and Development.

Taiwan's research has been more extensive than that of many of countries. Existing international data is often incomplete or is not compatible with the indicator selected by Taiwanese researchers. As well, the variety of methodologies for calculating the indicators in other countries makes comparison with Taiwanese data difficult. While not necessarily essential to the effective development of national goals, establishment of formal international exchanges of pollution intensity data could stimulate the growth of these programs in Taiwan, particularly if linked to a regional environmental issue which required multilateral cooperation.

Future Trends

Despite the above challenges, there is a significant amount of research activity underway in Taiwan, some of which has entered into the benchmarking phase of work. Several researchers in Taiwan believe that within five years, certain agencies such as the IDB or the EC will begin incorporating intensity concepts into their goal-setting strategies. However, most policy-makers are still in the early stages of understanding the uses and applications of pollution intensity metrics and there is no firm consensus yet on their future value or uses for as public policy tools. At this point, it is still very early to make predictions regarding the future direction of many of these programs. However, possible future trends include:

- *Linking analysis of pollution/resource intensity and economic value:* Ultimately, any cross-sector comparisons will require using the same denominator for each industry. With the exception of the Taiwan EPA's project on Cleaner Production Indicators for the Cement and Steel Industry and IDB's Cleaner Production Indicator for the Food Processing Industry, current metrics efforts only measure pollution intensity in terms of per unit product. However, as intensity databases become more complete, it will be easier to cross-reference the data with economic data. To make Taiwan's drive towards "high added value, low polluting, low resource intensive" development more concrete, it will eventually become necessary to begin comparing the value of certain industries against their environmental footprints. The CO_2 density index proposed by Professor Liang Chi Yuan is an initial attempt. For agencies interested in balancing environmental impact vs. value, financial measures will make a more meaningful denominator than product.

- *Selection of industry sectors for study will be based on strategic environmental concerns:* At the moment, selection of industry sectors for study is partially based on their significance as polluters and partially on the ease of study allowed by the volume of data already available. As methodologies for defining and measuring metrics become more defined, the industry sector databases will likely diversify. The process could probably also be quickened if the various service providers (CTCI, ITRI, etc.) are encouraged to combine their databases.

- *Increased linkages to ISO formats:* The MOEA has aggressively promoted ISO 14001 since the early 1990s, primarily out of concern that non-certified companies would be shut out of international export markets. Given the significant investment already made in ISO, it will most likely be in Taiwan's interest to promote some form of reporting or evaluation based on ISO standards

to demonstrate the overall quality of Taiwan's environmental management.[25] Furthermore, as experiences overseas have illustrated, any external reporting efforts undertaken by industry will require movement towards a set of standardized performance indicators. The draft ISO standards on EPE will most likely spur further interest in standardizing pollution intensity indicators. Once standard evaluation formats are developed, it will become easier to aggregate sector data for national policy considerations.

- *Growing linkages to total quantity/"bubble" management*: Officials in both the IDB and EPA have stated that Taiwan's environmental laws are moving away from simple emissions standards and towards a system of pollution permit allowances. Actual implementation of permitting systems will not occur in the short-term, but certain government agencies (e.g. Kaohsiung municipal government) have already started experimenting with pollution caps on a local basis. Developing an allowance system would likely require baseline data on average pollution intensity for an industry to help determine equitable allocations of pollution rights. As the system progresses, intensity benchmarks could potentially also form the basis for reducing the number of permits allotted or rewarding companies with superior performance.

- *Changes in the role of the Taiwan EPA:* Perhaps the most interesting aspect of metrics research in Taiwan is the opportunity it provides to the Taiwan EPA to change its role from policeman to partner. Historically, the EPA has primarily focused on managing emissions or effluents that leave the factory. Since 1996, individual departments within the EPA have begun to shift from policing to partnering with industry by providing information on pollution control strategies and technologies to meet regulatory requirements. In the past, such outreach efforts in Taiwan were strictly within the realm of the IDB. The Taiwan EPA's efforts to develop partnerships with business could lead to an interest in analyzing pollution intensity in order to guide its technical outreach efforts. Perhaps even more noteworthy, the Cleaner Production Indicators for the Cement and Steel Industries described in this paper will be the first time that the EPA has specifically focused on improving the environmental performance of compliant companies instead of simply pursuing non-compliant companies.

- *Involving business in the process of benchmarking:* There is already significant interest amongst Taiwan's leading companies in being able to benchmark their performance both locally and internationally. However, many companies have complained of a lack of available data to allow them to gauge their performance. As environmental performance becomes more of a competitive issue amongst companies and public policy becomes more metrics focussed, there will be growing support for gathering of data by industry associations.

- *Link to "Right-to-Know" policies:* At the moment, Taiwan has very little publicly available information on corporate environmental performance. Given the political difficulties associated with government establishing intensity goals, one way to generate pressure for improvement is to make benchmarking data

[25] IDB's 1999 budget includes technical guidance for Taiwanese companies that are preparing environmental reports.

available to the public. Industry laggards would then come under pressure from a number of stakeholders internally and externally to bring their performance closer to the industry average.

Appendix One: Program Profiles

Funding Agency	Project Title / (Sectors)	Goals
1) Air Pollution Bureau, EPA	Cleaner Production Indicators for the Steel and Cement Industries (Steel and Cement)	Establish environmental performance indicators for selected industrial sectors and benchmark performance of companies currently in the sector
2) Air Pollution Bureau, EPA	Strategies for Reduction of Greenhouse Gases (completed) (All Sectors)	Recommend policy approaches to reduce greenhouse gases
3) Coordination Office of Sustainable Industry (part of IDB of MOEA))	Industrial Sustainability Indicators for the Pulp & Paper Industry (Pulp & Paper)	Develop a set of sustainability indicators for the pulp and paper industry covering environmental, economic, and social aspects
4) Industrial Development Bureau, MOEA	Investigation and Pilot Implementation of Environmental Performance Evaluation in Factories (Integrated Circuits, Printed Wiring Board)	Develop a methodology for selecting and utilizing EPE indicators for selected industries
5) Industrial Development Bureau, MOEA	Handbook for Using Cleaner Production Techniques (completed) (Polyurethane, Integrated Circuits, Leather)	Develop a set of cleaner production indicators for private sector to use to assess their opportunities for implementing cleaner production
6) Technology Division, MOEA	Use of Cleaner Production Indicators in the Food Processing Industry (completed) (Food Processing)	Develop a set of cleaner production indicators for the Food Industry
7) Energy Commission, MOEA (proposed)	Name undetermined as yet (All Sectors)	Benchmark energy efficiency to determine standards for reasonable energy use for new factories or expansions
8) Energy Commission, MOEA	Annual Energy Efficiency Report (All Sectors)	Track energy use and identify opportunities for energy efficiency improvements in high-use sectors
9) Water Resources Bureau, MOEA	A Study on the Rational Limit of Multipurpose Water Use (All Sectors)	Benchmark water use by sector

1) Program Name: Cleaner Production Indicators for the Steel and Cement Industries
Sponsoring Agency: Taiwan EPA (Air Pollution Bureau)
Implementing Organization: Industrial Pollution Control Corps (IPC)
Project Timeframe: July 1998- January 2001

Program summary:
The Taiwan EPA's Air Pollution Bureau has commissioned a study to develop a set of metrics to benchmark the environmental performance of the steel and cement industries. For the short-term, the EPA hopes to use the program to identify the most efficient companies in terms of minimizing pollution, maximizing resources, and encourage leading companies to share their experience with the rest of the industry. By offering guidance instead of imposing stricter standards, the EPA hopes to develop a better working relationship with industry while simultaneously promoting further environmental performance improvements among companies that are most likely already in compliance with emissions standards. The EPA may also consider utilizing some form of public disclosure of data to create pressure on businesses to improve.

In the long-term, the EPA hopes to develop indicators and information that can provide the foundation to compare different industry sectors in terms of environmental impacts and economic contributions. The project's final analysis will include examining pollution per unit of product, per value of output, per return on investment, and per unit of resources consumed. Ultimately, the EPA hopes the project will be a first step towards documenting the links between costs, profits, and pollution performance to help drive investment decisions within the private sector and policy decisions at the government level. Each year the project will focus on a new set of three industries. Priority will be placed on industries that are heavy contributors to air pollution.

Metrics system:
Metrics under this program are divided into three categories: environmental condition indicators (ECI), operational performance indicators (OPI), and management performance indicators (MPI). Within each of these broad categories, indicators are broken down into further sub-categories. For example, the ECI category includes the sub-categories: facility level indicators, local indicators, and indicators for global issues.

Proposed Sample Metrics:

ECI	*OPI*	*MPI*
Ambient air quality near factory	Volume of energy used per unit product	Percentage of time spent by management on environmental topics
Water volume used per unit of product	Cost of operating pollution control equipment	Percentage of employees who receive environmental awareness training
Volume of NOX per unit of product	Costs for maintaining pollution control equipment	Funds devoted to supporting local environmental activities
Volume of solid waste per unit of product		Total investment in pollution control equipment

2) Program Name: Strategies for Greenhouse Gas Emissions
Sponsoring Agency: EPA
Implementing Organization: Academica Sinica
Project timeframe: Completed in 1998

Program summary:
The Taiwan EPA commissioned Professor Liang Chi Yuan of Academica Sinica to identify potential policy tools to promote reductions in industrial greenhouse gas emissions. Professor Liang reviewed a number of options including carbon taxing, emissions trading, and structural adjustment of Taiwan's industrial base. Part of his final recommendations included restructuring the industrial base to move away from industries with high-CO_2 emissions and low-value added. As a guideline for the restructuring process, Professor Liang proposed a carbon dioxide density index based on CO_2 output over added value. The recommendations have been taken under consideration by the EPA.

Metrics applied:
Carbon dioxide density defined as CO_2 emissions divided by added value.

3) Program Name: Investigation and Pilot Implementation of Environmental Performance Evaluation in Factories
Sponsoring Agency: Industrial Development Bureau
Implementing Organization: Industrial Pollution Control Corps
Project Timeline: June 1998 - June 1999, but the program will likely be extended for one more year
Program summary:
The project will develop a methodology to assist companies in selecting environmental performance indicators most relevant to their own factory situation, corporate culture, and ISO system. IDB has been actively promoting ISO 14000 for several years, but has found that companies have difficulty in documenting their progress. Many companies have detailed data (including per product unit ratios), but do not analyze it in a structured or consistent fashion. The Industrial Pollution Control Corps' role is to support two companies in the integrated circuit and printed circuit board industries to: 1) select EPE indicators appropriate to their company; 2) enhance the ability to gather the necessary data for the indicators; and 3) provide an analysis of the data including defining a "reasonable" range of values for the company to use as a performance benchmark. Much of the data will be analyzed in terms of per product unit. The project has been budgeted for one year, but will likely be extended to allow for development of methodologies for other industry sectors.

Metrics applied:
At the moment, the Industrial Pollution Control Corps have developed a list of 130 potential indicators and expect the participating companies to select approximately 10 indicators to use. Indicators will be grouped under the categories of environmental condition indicators, environmental performance indicators, and management performance indicators.

4) Program Name: Handbook for Using Cleaner Production Technology
Sponsoring Agency: Industrial Development Bureau, MOEA
Implementing Organization: Union Chemical Labs, ITRI

Project timeframe: Completed

Program summary:
The goal of the program was to develop a series of indicators that could be used by factories to identify opportunities to improve their environmental performance through changes in the production process. A guidance document explained the indicators and included a detailed methodology for calculation of data and analysis of the results. Documents were prepared for a total of three industry sectors: integrated circuits, leather processing, polyurethane industry. The project was a component of a larger project given to ITRI's Union Chemical Labs by the Industrial Development Bureau's section on Waste Minimization.

Metrics applied:[26]
The system was based on three indicators:

1) Waste generation index (WGI) defined as pollution output divided by production volume
2) Energy consumption index defined as energy usage divided by production volume
3) Hazard index defined as volume of hazardous substances contained in each unit of product, multiplied by a coefficient

The waste generation index (WGI) is further broken down into sub-indicators for chemical raw materials/production, solid waste/production, wastewater/production, and air emissions/production. Chemical raw materials are further broken down into sub-sets for each individual input. Similarly, the energy consumption index is broken down into two separate sub-indicators of fuel consumption and energy consumption.

All of the above indicators are calculated for each stage of the production process. The results from each stage are then added together to form a composite figure for the entire facility.

Over the course of the research, ITRI gathered pollution performance data from companies participating in the project. However, the information is considered confidential. The primary goal of the project was not to establish a database of information, but rather to establish a methodology for businesses to use to assess their own performance.

5) Program Name: Industrial Sustainable Development Indicators for the Pulp & Paper Industry
Sponsoring Agency: Coordination Office for Sustainable Industry (COSI) of IDB, MOEA
Implementing Organization: Foundation for Environment and Development (FED)
Project Timeframe: Report due in May 1999; may be extended for an additional year

[26] *Handbook on Use of Cleaner Production Indicators in the Leather Processing Industry*, Ministry of Economic Affairs Industrial Development Bureau, 1997. Handbook is in Chinese.

Program summary:
COSI commissioned the Foundation for Environment and Development to develop a set of sustainable development indicators for the pulp and paper industry. COSI hopes that the indicators will provide a framework for both government and business to monitor the overall sustainability of the pulp & paper industry in terms of its environmental, social, and economic dimensions. The pulp & paper industry was selected due to the large volume of existing data already available on industry as well as the strong working relationship between IDB and the industry association.

COSI views the program as a pilot program in what will likely become a long-term effort to develop a range of sector specific sustainability indicators. COSI hopes that the pilot project can serve as a model to encourage other departments of the MOEA as well as individual industry associations to develop indicator sets for their sector.[27] In addition to providing useful information to policy-makers, COSI also hopes that the information can be used to benefit individual companies with the best performance in their industry. COSI does not have concrete recommendations yet, but envisages possible benefits such as securing fewer inspections by environmental agencies for the leaders in the field, boosting exports by demonstrating responsible environmental management, or other related measures.[28]

Metrics applied:
FED is designing a "pressure-state-response" system based on the "triple bottom line" concept. Indicators will be divided into environmental, economic, and social topics to capture the multiple dimensions of sustainability. The project will establish a basic set of categories which will then be subdivided into indicators that can be tailored to match the characteristics of each individual industry. The economic category will likely focus on national competitiveness; the environmental category will focus on energy consumption, recyclability, and water; and the social category will focus on innovation ability and transparency of information.

The proposed matrix will resemble:

Domain	Category	Pressure	State	Response
Economic	National competitiveness			
Environmental	Energy consumption			
	Water			
	Recyclability			
Social	Transparency of information			
	Innovation ability			

6) Program Name: Use of Cleaner Production Indicators in the Food Processing Industry
Sponsoring Agency: Technology Division, MOEA
Implementing Organization: Union Chemical Laboratory, ITRI

[27] The MOEA has a number of divisions that focus on the development of specific industry sectors. COSI is hoping to encourage industry-specific departments to incorporate environmental performance goals into their planning.
[28] COSI would have to offer any such recommendations to the Taiwan EPA, since it is in charge of enforcement of environmental regulation.

Project Timeline: Completed in June of 1998

Program summary:
ITRI developed a set of 10 indicators for use by the food processing industry in identifying opportunities for cleaner production. The study collected performance data from a range of companies within the food processing industry. Surveys focussed on GMP[29] certified companies under the assumption that they would demonstrate industry best practices and therefore set the benchmark.

Metrics applied:[30]
Percentage of waste recycled/reused; tons of solid waste per dollar of value created; percentage of water recycled/reused; amount spent on energy per dollar of value created; amount spent on pollution control per dollar of value created; process packaging waste per number of ton of packaging used

7) Program Name: Proposed Benchmarking Project
Sponsoring Agency: Energy Commission
Implementing Organization: Energy Technical Service Center (ETSC)
Program timeframe: multi-year

Program summary:
In response to the interest in efficiency prompted by the Kyoto Protocol and Taiwan's tight energy supply margins, the Energy Commission is considering a project to audit the energy efficiency of industrial equipment and production processes in Taiwanese industry. The project would benchmark energy use for the manufacture of specific products as well as 10 technologies per year.

The long-term goal is to establish benchmarks for "reasonable" energy usage in a factory based on production process and scale. The benchmarks would then be used as a reference point to review applications for energy allotments from new factories or expansions of existing factories. The project would also survey the energy efficiency of existing technologies to allow the Energy Commission to improve its technical guidance programs and further refine its performance benchmarking.

ETSC has been regularly conducting energy audits at industrial sites on behalf of the EC and private clients for many years. The proposed project would draw on their existing database of knowledge as well as require substantial additional fieldwork. Budgeting for the benchmarking aspect of the project will be formally approved with the completion of the government budgeting process.

Metrics applied:
Still in the proposal stage, but will include per unit product ratios.

8) Program Name: Annual Energy Efficiency Report
Sponsoring Agency: Energy Commission

[29] GMP is a certification system used by the food and pharmaceutical industries and stands for "good manufacturing practices".
[30] "Use of Cleaner Production Indicators in the Food Processing Industry", Wang Ren and Huang Wen Hui, 1998. Article is in Chinese.

Implementing Organization: Energy and Resource Laboratories, ITRI
Project timeframe: Annual

Program summary:
The Energy Efficiency Report was initiated roughly seven years ago in accordance with the Law on Energy Resources. Under the legislation, companies which purchase more than 1000 kilowatts per year from Taiwan Power are required to report annually on their energy use and improvements in energy efficiency. Roughly 1,800 different factories from steel, cement, paper, petrochemical, textile, food, electroplating, and electronics sectors are expected to report on an annual basis.[31] ITRI is responsible for compiling the results and benchmarking each company's performance against the standard for its industry. Results are compiled in an annual report containing data on aggregate usage by different industry sectors as well as averages per ton of product. The report includes general information on energy efficiency strategies applied within different sectors as well as sample case studies.

Metrics applied:
Sectoral comparisons of overall energy use patterns and trends, sources of energy (e.g. fossil fuels, etc.) and average energy use per unit of product for select product categories,

9) Program Name: A Study on the Rational Limit of Multipurpose Water Use
Sponsoring Agency: Water Resources Bureau
Implementing Organization: Tamjiang University
Project timeframe: 1996-1999

Program summary:
The goal of the program was to establish a set of indicators and data on water use by the industrial sector to serve as a reference point for reviewing applications for water rights from new factories or expansions of existing facilities. Currently, the WRB assesses requests in terms of available water supply, without specific reference to the efficiency with which the applicant will use the resources. With the growing emphasis on efficiency, the WRB is seeking to establish a range for "reasonable" water use volumes within various industry sectors to serve as a baseline for assessing requests. A secondary goal was to identify facilities that are under-reporting their water use and illegally tapping into underground water supplies. Over the medium to long term, the range will most likely be tightened and be used as an efficiency standard. The study is due to be completed this year, but it is uncertain how quickly the benchmarks will be incorporated into policy decisions.

Metrics applied:[32]
The program had originally expected to use a ratio of water used per unit of product manufactured. However, during the course of the project, the researchers changed their approach to base their benchmarking on:

[31] *Annual Energy Efficiency Report*, Ministry of Economic Affairs, Energy Commission, 1998. Report is in Chinese only.
[32] *A Study on the Rational Limit of Multipurpose Water Use,* Lu Guo Hsing (Tamjiang University), Ministry of Economic Affairs Water Resource Bureau, 1998. Report is in Chinese. English title provided by author.

- Cubic Meters per Day (CMD) per unit of facility size
- CMD per unit of floor space
- CMD per employee
- CMD per dollar of operating cost

Appendix Two: Relevant Government Agencies

Responsibility for industrial environmental issues is divided primarily between the Taiwan EPA and the Industrial Development Bureau (IDB) within the Ministry of Economic Affairs (MOEA). Water and energy resources are managed separately by the Water Resources Bureau (WRB) and the Energy Commission (EC), both of which are under the MOEA. Broader initiatives on sustainability and related metrics are also divided among a number of other organizations including the National Council for Sustainable Development (NCSD) and the National Science Council (NSC).

A brief summary of each organization is given below:

Taiwan EPA – Responsible for maintaining environmental quality and managing industrial pollution. Areas such as nature conservation/biodiversity, land use planning, and nuclear issues are not directly under the Taiwan EPA's jurisdiction. Traditionally, the EPA has shown little interest in what happens within the factory walls and has focused its efforts on developing standards for pollution output. Recently, the EPA has begun holding workshops for industry on pollution control technologies in conjunction with efforts to tighten standards.

IDB – Responsible for managing and implementing Taiwan's industrial development policies. IDB's 7th division is responsible for working with industry to improve environmental performance. The IDB is often described as the carrot while the EPA is the stick.

Water Resources Bureau (WRB) – Responsible for developing and allocating Taiwan's water resources. Maintaining water quality falls under the portfolio of the EPA. Traditionally, the WRB has been more concerned with developing water resources than promoting conservation. The WRB is under the MOEA.

Energy Commission (EC) – Responsible for managing growth and allotment of Taiwan's energy resources. The EC is under the MOEA.

National Council on Sustainable Development (NCSD) – The NCSD does not have an official staff. The Secretariat's function is provided by the Taiwan EPA's Office of Science and Technology Advisors. The NCSD is composed of eight committees, each of which is led by a different government agency depending on the focus of its work. Each Committee pursues its own course of work and reports back to the Secretariat. The overall role of the NCSD is to coordinate Taiwan's sustainable development policies by 1) increasing awareness around sustainability issues amongst different government agencies; 2) raising a warning flag on new trends or developments in global environmental issues.

Implementing Agencies
Industrial Technology Research Institute (ITRI) – As Taiwan's largest industrial technology research organization, ITRI played a key role in leading technology transfer to support Taiwan's industrialization. ITRI now has research groups dedicated to environmental and resource issues in the Union Chemical Laboratories, Energy and Resource Laboratories, and the Cleaner Production Center.

China Technical Consultants Inc. – a quasi-government consulting firm that works primarily with government agencies on industrial pollution and resource management. CTCI is comprised of three branches, each of which works primarily with one government agency:

Industrial Pollution Control Corps – works primarily with IDB to provide technical consulting/guidance to industry on pollution control.

Energy Technical Service Center – works primarily with EC to provide energy auditing and training in energy efficiency to industry.

Environmental Science and Technology Center – works primarily with the Taiwan EPA on issues related to regulatory implementation.

Foundation for Environment and Development – responsible for implementing Taiwan's eco-labeling program as well as work in ISO certification. FED was formerly a part of ITRI before becoming an independent foundation.

Academica Sinica – Taiwan's most prestigious research organization with labs and scholar-experts covering fields from natural and physical sciences to social sciences.